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XI.—DRAINING SYPHON.

The Gold Vulcan Medal *was this Session given to* R. Cowen, *Esq. of Carlisle, for his* Draining Syphon, *a Model of which has been placed in the Society's Repository.*

Sir; Carlisle, April 21, 1827.

In submitting to the Society of Arts, &c. a communication on an instrument in such general use, and so well known as the syphon, I would particularly draw the attention of the committee to the fact, that though the theory of the syphon is universally understood, yet it has not been applied in practice for raising water over the highest levels, which the law of the atmospheric pressure and theory have assigned to it. On the common principle, I believe from twelve to fourteen feet rise has been the extent attainable in the practical uses of the syphon, although the weight of the atmosphere, at its lowest point of pressure, is an equipoise to a column of water of thirty-two feet in height. If a syphon of any height be filled with water, it may in theory be considered a torricellian vacuum; and it is only necessary to shorten one of the legs below the height of a column of water equal to the weight of the atmosphere, to give the other a preponderance, and the water begins to flow from the longer leg, and in theory should continue to do so. Water, however, has an affinity for air and some of the gases, and when exposed to them under the pressure of the atmosphere, absorbs a portion of each. This affinity, I believe, may be considered a given force; it is destroyed by boiling, and the air is expelled; it is also diminished as the atmospheric pressure is removed, and a portion of air is set free at something less than half the weight of the atmospheric column. The weight of the opposing columns of water suspended in the two legs of the syphon, it is evident, must diminish the atmospheric pressure, at the highest bend, in an inverse ratio to the height of the shorter leg or column; when this exceeds twelve to fourteen feet, air is set free, displaces the water at the highest bend of the syphon, thus dividing the two columns, and entirely preventing that continuous flow which would otherwise take place were water to contain no gas or air. To devise means to remove this defect in the action of the syphon at the higher levels, is the object of the invention which I now submit to you.

I am, Sir,
&c. &c. &c.
ROBERT COWEN.

A. Aikin, Esq.
Secretary, &c. &c.

Reference to the Engraving.—Plate X.

Fig. 1, *a a*, part of the quarry to be drained; *b*, a level lower than the bottom of the quarry, which in this case is two hundred yards off, where the water is to be discharged; *c*, the highest ground, over which the water is to be conducted: *d e* and *f*, three different rises, over which the pipes pass—they are farther apart than here shown; *g g h h*, the lead pipe composing the two legs of the syphon; *i*, a forcing-pump, on the common principle fixed below the surface of the water, having a hinged valve at *j*, fig. 2, and an open working-box with a similar valve *k*. The two valves *j* and *k*, when the syphon is in action, are opened by the force of the water flowing through the pump in its passage to the syphon; *l* is the handle or lever for working the pump, which is placed at a convenient height above the water at all times; *m* is a close iron receiver, shown larger in fig. 3, having inserted at one end, at the lower side, at *n*, the shorter or ascending leg of the syphon *g g*, and at the other end, at *o*, the longer or descending leg *h h;* at the upper side at both ends are inserted two air pipes *p p*, which may be small, joining with the syphon pipe at the highest bends, as shown at *d e* and *f*, with a regular slope into the receiver to allow the air to ascend into it, which would otherwise remain at the highest elevations of the pipe; *q* is a small valve fixed at the highest point of the receiver, to allow the whole of the air to escape through the valve when the water is forced up by the pump; for this purpose the pump *i* and pipe *g* must be able to supply water quicker than the pipe *h* will carry it off.

To put the syphon into action, it is only necessary to pump the water up into the receiver, to expel the air through the valve, and also through the longer leg of the syphon. The syphon will then continue in action without aid till the receiver is again filled with air, which is again expelled by a few strokes of the pump, and only requires to be repeated every twelve hours, when the rise exceeds from twelve to fourteen feet, varying with the unequal pressure of the atmosphere; but when less than the above height, it continues to flow without intermission for any given time, and acts on the principle of the common syphon.

The following are Directions to be observed in laying the Syphon to suit different situations.

1st. In laying the pipes of the syphon, it is necessary to give them a regular slope to admit the air to pass forwards into the receiver, or to the highest bends, which must have either an air receiver to each bend, or a pipe inserted to convey the air into a general receiver.

2nd. When sufficient descent from both sides of the air receiver can be obtained, no air pipes will be required.

3rd. In situations where it may be necessary to carry the pipes over more than one elevation, and the second exceeds the height of the first, a separate receiver will be required for each elevation. On this construction, viz. with more than one receiver, it is necessary to adopt the following expedient for closing the valves in succession, as the air is expelled from each receiver.

Description to Figs. 4 *and* 5.

Fig. 4; *r* is the lower valve in the receiver *s*, which is opened by the force produced by pumping, and the air escapes; *t* is an inverted valve, with a float or buoy *v* fixed upon the valve-spindle in the centre of the cup *u*. While air only is expelled, the inverted valve will remain open; but when the water is forced out and fills the cup, the float will rise and close the valve at the same time; thus the water being stopped from flowing out, will be forced forward to any number of receivers in succession; *w* is a very small outlet-pipe inserted into the bottom of the cup *u*, through which the water escapes slowly; as the cup is emptied, the float is lowered, and the inverted valve again opened—a position necessary to allow the air to escape at the next pumping.

Another method described for closing the Valve.

Fig. 5; *q* is a valve placed in a cup, as shown in fig. 1;

on the cup is mounted a lever with a counter-weight x at one end, and a small pendant receiver y at the opposite end; z is a conducting tube inserted into the edge of the cup, to convey the overflowing water into the receiver, which as it fills, loads the valve, and prevents the escape of the water, and thus forces it forward as before described to any number of receivers. As it may be expected that the first cistern will collect the greatest portion or nearly the whole of the air, the others following in succession may be proportionally smaller.

In making the joints of the lead pipes, I used tinned copper hoops, and made the joints square or jump joints, and soldered them over in the common manner. The joints of the air cistern were made with iron cement, with a portion of red lead in powder added, and mixed up with oil, in place of water, as in the usual way, and caulked into the joint in the same manner as common iron cement.

Carlisle, Currock Cotton Works,
April 27, 1827.

Sir;

I beg leave to trouble you with a few observations, in addition to the communication on the improved syphon which I recently had the honour of submitting to the Society of Arts; and I would observe, in the first place, that in my former communication I have designated the air vessel an air *cistern*, but in the following remarks I have substituted what I conceive to be a more appropriate term—that of air *receiver*, an alteration I should wish to have made in the original paper and in the section.

On referring to the plan, it will be observed that the water delivered by the syphon passes through the air receiver, and must of course rest there a given time, or in proportion to the quantity of water in the receiver, compared with the quantity discharged, and the time will consequently vary from a quarter to half an hour. This rest is necessary to allow the air to separate—as the affinity between air and water increases as the quantity of air held in solution diminishes, and *vice versâ*, and time is also required in addition to diminished pressure, to effect a complete separation. When the water has not had sufficient time to rest in the receiver, air bubbles collect in the descending leg of the syphon, and diminish the quantity of water discharged materially.

In the first experiment I had a small receiver with a screwed plug or cap at the top, attached to the highest elevation of the syphon, and an inch pipe, having a stop-cock, introduced between the syphon and the receiver, for cutting off the communication, to ascertain the quantity of air collected in a given time. When the syphon, under this arrangement, had been in operation a short time, the discharge gradually diminished, and in three hours nearly ceased. The two legs of the syphon were now plugged up, and the connexion cut off by means of the stop-cock, the cap unscrewed, and the quantity of air then in the receiver ascertained. The cap and stop-cock were again adjusted, and the descending or longer leg of the syphon shaken a little from the lower end upwards to the receiver. The stop-cock being again closed, and the receiver examined as before, it was found to contain a considerable additional quantity of air, and the water had consequently descended into the pipe and occupied the space, proving, I think pretty satisfactorily, the three following facts: first, that air had separated from the water flowing through the pipe; second, that it had not been carried forward, but had attached itself to the interior of the pipe, in small bubbles; third, and that air bubbles so attached increased the friction to such a degree, as nearly to prevent the discharge. This experiment was repeated with some little variation, and the first result confirmed. The size of the large air-receiver was now determined, which I must remark was intended to be double the present size; and I had in the first instance two vessels connected together, but one of them on trial proving defective was detached, and the single one only used. The discharge, however, after twelve hours running, diminishes about one eighth to one tenth in quantity; but for several hours no apparent diminution takes place. Hence the necessity of allowing time for the water to rest in the receiver, by keeping a sufficient quantity in it, and of having the receiver of large capacity, compared with the size of the pipe.

It may also be necessary to observe, that the syphon was in full operation upwards of three weeks, without requiring any air to be forced out by the pump, no air for that period having collected in the receiver. This, however, occurred under the following peculiar circumstances :—on the 3rd and 4th of March, a very extraordinary quantity of snow fell, accompanied with a high wind, which drifted the snow into the quarry nearly to the summit; and for several days a rapid thaw, with a fall of rain, succeeded, which, together, filled the quarry with water to an unusual height, so as to reduce the column of water in the shorter or ascending leg of the syphon to 8·5 or 9 feet. After this period, the syphon required no pumping till the column had reached 14 feet, exceeding the height at the first commencement fully two feet, at which elevation air collected in the receiver, and it required pumping out night and morning. The barometric column, however, at the former period, stood at about one inch and a quarter lower than it did in the latter, which would make some difference, and should be taken into account; but it does not satisfactorily explain the whole difference, which would, in all probability, *exceed* two feet, as the syphon collected air from the commencement of the first trial, and the minimum of pressure at which air might have then separated, could not be ascertained. It is not therefore *certain* that twelve feet is the minimum height at which air is set free, when the water is fully saturated. It is probable, under such circumstances, at a much lower pressure, as the above is a single instance in which the syphon operated for so long a period without pumping, and the only one with a mixture of snow-water. We have the authority of a number of eminent chemists (with the exception of Gay Lussac, and Humboldt), for supposing, that the water obtained from melted snow contains little or no air; and if the law of absorption be correct as established by Dr. Henry and Mr. Dalton, that water will hold in solution a quantity proportionate to the pressure, or if it absorbs one twenty-fifth under the pressure of one atmosphere, two twenty-fifths under the pressure of two, &c., the same law will hold in diminishing it below the pressure of one atmosphere to that of a vacuum; so that we might presume that in a syphon where water is fully saturated, air would separate at a much lower pressure; yet, whether it is that water is seldom fully saturated, or that the air is carried forward when it passes rapidly through the syphon, as is the case with a short one having a considerable fall in the longer leg, I shall not presume to determine, but, in practice, it does not collect under such circumstances in a common syphon of moderate height of five or six feet. A little more experience, therefore, and repeated observation, are necessary to determine the minimum height at which air will separate from water, and this will unquestionably vary with the proportion of air held in solution, with temperature, with the length of the syphon and the velocity of the water passing through it; and other circumstances.

I am, Sir,
&c. &c. &c.
ROBERT COWEN.

A. Aikin, Esq.
Secretary, &c. &c.

CERTIFICATES.

Howrig, near Carlisle,
Sir; April 21, 1827.

Having had under my direction the improved syphon constructed by Mr. Cowen, for draining the stone quarry at Howrig, and being also acquainted previously with the great labour, expense, and difficulties, at certain seasons, in clearing away the water by the common pump, I can with great confidence give my testimony of its having answered fully the intended purpose. It is now comparatively managed with little or no trouble or expense, and by its regular unceasing operations, greatly contributes to the profitable working of the quarry.

The diameter of the pipe is only one inch, and it delivers, on an average, about 3,000 gallons of water per twenty-four hours. When the surface of water exceeds from twelve to fourteen feet below the bottom of the air cistern, a quantity of air collects, which requires to be displaced by a few strokes of the pump night and morning, but does not exceed, in the expanded state, more than from six to ten cubic feet. A few minutes each day are sufficient to expel the air, and the labour is so simple and easily performed, that any of the boys are equal to the task. It may be necessary to observe, that no air can possibly enter through the pump, it being completely immerged under the surface of the water; and that portion of the pipe which was at the surface of the water when the air began to collect, has been accurately examined, but no defect can be discovered, as no water issues from any part of it, even when the force of the pump is applied. I have great pleasure in being able to state, from considerable experience, the superiority of this method of draining such quarries, and am of opinion it is the most economical ever yet discovered, and may be applied for draining other quarries in this neighbourhood, or to any purpose or situation where sufficient fall can be obtained.

I am, Sir,
&c. &c. &c.
WILLIAM WOOD.

A. Aikin, Esq.
Secretary, &c. &c.

SIR; Carlisle, April 18, 1827.

I have much pleasure in bearing testimony to the ingenuity and usefulness of Mr. Cowen's improved syphon. I lately accompanied Mr. Cowen and Mr. Studholme to Howrig, and examined the syphon, which was then in full operation, and appeared to answer effectually the purpose for which it was intended.

I am, Sir,
&c. &c. &c.
THOMAS BARNES, M. D.

A. Aikin, Esq.
Secretary, &c. &c.

Kingmoor House, near Carlisle,
SIR; April 26, 1827.

I have examined Mr. Robert Cowen's improved syphon, at present drawing water from a freestone quarry at Howrig, near Carlisle, which appears perfectly to answer the intended purpose.

I took levels and such dimensions as enabled me to draw a correct plan and section, showing the height which the syphon draws the water, and the lengths of its respective parts, which I suppose Mr. Cowen will send you.

I am, Sir,
&c. &c. &c.
JOHN STUDHOLME.

A. Aikin, Esq.
Secretary, &c. &c.